

Progress on Design and Demonstration of the 4Mb Chalcogenide-based Random Access Memory

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Abstract

Today the state of the art for space non-volatile memory is a radiation tolerant 256kbit SONOS device requiring milliseconds to write (erase) and that can be written to a few thousand times. System designers requiring a more dense, low-power, fast-access, radiation-hardened, non-volatile memory have been forced to work around this problem using a variety of techniques, including commercial devices repackaged for use in space or volatile memory backed by batteries.

Phase change nonvolatile memories are emerging as viable candidates for the next generation of solid-state memory products. Most commercial research is focused on the chalcogenide material ($\text{Ge}_2\text{Sb}_2\text{Te}_5$) used for rewritable optical media (CD-RW and DVD-RW). This alloy is the product of a long material development effort, starting in 1968. Following initial investigations into its suitability for solid-state applications as well as optical products, improvements in device modeling provided increased optimism that memory devices could be economically produced that might rival or even surpass existing solid-state memory - both nonvolatile and volatile.

The Air Force Research Laboratory initiated a program in 1999 to research and develop chalcogenide technology for space applications. The Chalcogenide-based Random Access Memory (C-RAM) program combines the phase-change expertise of Ovonyx, Inc. with the radiation hardened CMOS processing capability of BAE SYSTEMS to focus on a radiation-hardened, fast, low-power, high-endurance nonvolatile memory.

During the first stage of the multi-year research program, BAE SYSTEMS and Ovonyx successfully integrated the chalcogenide material used for phase-change applications in re-writable optical storage ($\text{Ge}_2\text{Sb}_2\text{Te}_5$) with BAE SYSTEMS' $0.5\mu\text{m}$ radiation hardened CMOS to produce 64kb arrays. The test structures ranged from simple two- and four-point-probe material characterization macros, such as sheet resistance monitors and chalcogenide memory elements, to fully wired $8\text{k} \times 8$ arrays. Electrical testing and radiation effects testing results of this Chalcogenide-based Random Access Memory (C-RAM) program showing considerable success have been reported in the past.

The first generation of C-RAM memory is designed to greatly exceed the existing solutions (in density, write speed, endurance) and close the gap that exists between requirements and availability. Based on the success of the 64kb C-RAM program, the Air Force Research Laboratory has recently funded BAE SYSTEMS to design, fabricate and deliver a 4M-bit C-RAM product implemented in $0.25\mu\text{m}$ radiation-hardened CMOS. The program will result in prototype devices 4Q04 and flight parts 3Q05.

In this paper we present a description of the architecture and design of the initial C-RAM 4M-bit non-volatile memory. In addition, results from the C-RAM process transition from $0.5\mu\text{m}$ to BAE SYSTEMS' radiation hardened $0.25\mu\text{m}$ process will be presented.